# NASA SBIR/STTR Technologies

## T1.01-9946 - High-Fidelity Prediction of Launch Vehicle Lift-off Acoustic Environment

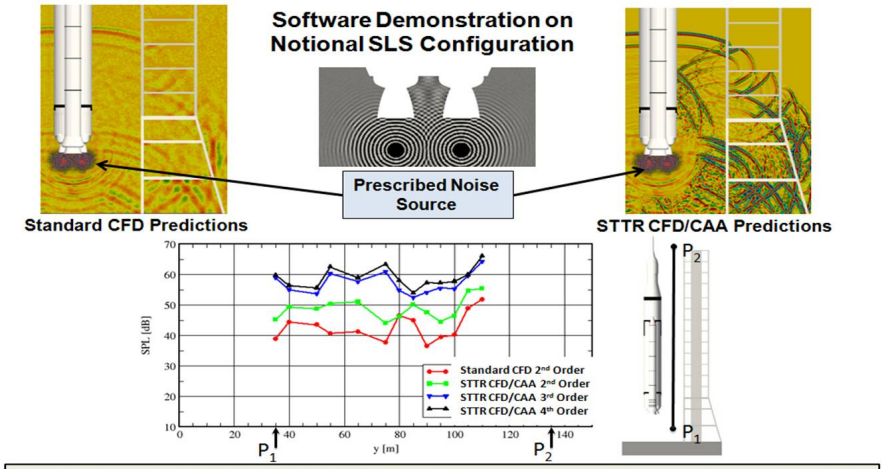

PI: Robert Harris

CFD Research Corporation - Huntsville, AL


## Identification and Significance of Innovation

- Launch vehicles experience extreme acoustic loads during liftoff driven by the interaction of rocket plumes and plume-generated acoustic waves with ground structures.
- Higher fidelity liftoff acoustic analysis tools are critically needed to characterize the acoustic environment and enable design mitigation measures and optimization of launch pad designs for SLS and commercial launch vehicles.
- Currently employed predictive capabilities to model the complex turbulent plume physics are too dissipative to accurately resolve the propagation of acoustic waves throughout the launch environment.
- This project will deliver a high-fidelity coupled CFD and Computational Aeroacoustics prediction tool that integrates unsteady hybrid RANS/LES CFD with a high-order accurate Discontinuous Galerkin (DG) scheme for non-dissipative acoustic field propagation.
- An innovative hybrid method will be developed to transmit launch-induced acoustics.

Estimated TRL at beginning and end of contract: ( Begin: 3 End: 7 )




STTR Coupled CFD/CAA Method Delivers Drastic Acoustic Propagation and Sound Pressure Level Predictions Improvements over Standard Computational Approaches

## Technical Objectives and Work Plan

The overall objective is to develop a comprehensive high-fidelity computational fluid dynamics/computational aero-acoustics (CFD/CAA) simulation system for launch vehicle liftoff acoustic environment predictions. The developed tool will couple the existing highly-scalable NASA production CFD code, Loci/CHEM, with a high-order accurate discontinuous Galerkin solver developed in the same production framework, Loci/THRUST, to accurately resolve and propagate acoustic physics across the entire launch environment. Validation will also be carried out against the NASA Ares Scale Model Acoustic Test (ASMAT) data to demonstrate the ability of the coupled CFD/CAA code to resolve the observed spectrum of acoustic frequency content. The specific objectives of Phase II study are summarized as follows:

- Refinement and optimization of discontinuous Galerkin solver and CFD/CAA coupling procedure for production use;
- Development of production tools for curved mesh generation in complex geometries to fully realize benefits of modern high-order methods including the discontinuous Galerkin method;
- Development of adaptive overset/Chimera CFD/CAA coupling approach that makes use of penalty methods to transmit acoustic signal from CFD to CAA and absorb reflected/diffracted content; and
- Deliver, test, and optimize the software on NASA HPC systems, perform verification & validation studies, assist MSFC personnel w/application, demonstrations, and offer user training.

## NASA Applications

- Definition of lift-off environments for new launch vehicle designs;
- Acoustic loading predictions from first principle simulations for specific launch vehicle configurations;
- Analysis of launch pad and liftoff environment noise suppression techniques;
- Launch vehicle payload and instrument acoustic loads predictions; and
- Commercial aircraft airframe and landing gear noise predictions.

## Non-NASA Applications

- Launch environments by commercial launch service providers such as ULA, ATK, Boeing, Space-X and Orbital Sciences.
-Acoustic loads predictions by payload system and sensitive instrument developers, particularly for one-of-a-kind DoD, NRO, and NOAA satellites.
- Conventional and STOVL aircraft jet acoustics

## Firm Contacts


Robert Harris
CFD Research Corporation
701 McMillian Way NW, Suite D
Huntsville, AL, 35806-2923
PHONE: (256) 726-4800
FAX: (256) 726-4806